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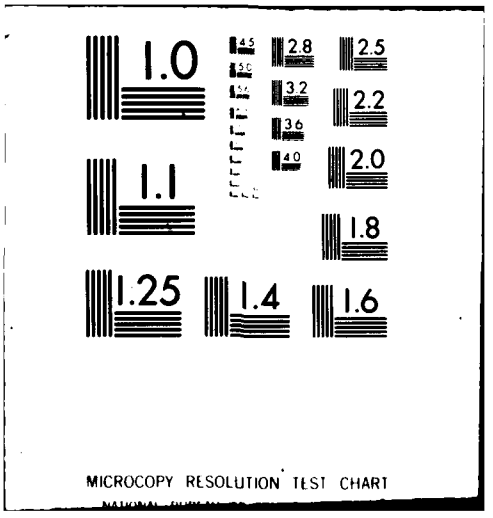
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DESIGN AND FABRICATION OF QUADRUPOLE ION MASS SPECTROMETER FOR UPPER ATMOSPHERE

Edgar J. LeBlanc

Wentworth Institute of Technology
550 Huntington Avenue
Boston, Massachusetts 02115

Final Report
1 October 1977 - 30 September 1981

30 September 1981

Approved for public release; distribution unlimited

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The material used in this report describes the design and fabrication of component parts and assemblies used in an Upper Atmosphere Composition Research Program conducted by the Composition Branch of the Aeronomy Laboratory for the AFGL.

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WENTWORTH INSTITUTE OF TECHNOLOGY

Final Report

Contract No. F19628-78-C-0017

INTRODUCTION

Contract No. F19628-78-C-0017 was initiated with Wentworth Institute of Technology on 1 October 1977, by the Air Force Geophysics Research Laboratories (AFGL), Hanscom Air Force Base, Bedford, Massachusetts, for participation in the Upper Atmosphere Research Program being conducted by the Air Force Systems Command of the United States Air Force.

The contract required that Wentworth Institute of Technology provide the personnel, facilities and materials necessary to design, detail, fabricate, field service, analyze, evaluate and deliver mechanical components and assemblies for aerospace instruments and support equipment.

In order to fulfill this contract the following activities are carried out. Engineering liaison was conducted with AFGL personnel in order to establish design requirements for instruments and support equipment. Mechanical design and detail of mechanical components preceded the preparation of assembly drawings. The Machine Shop then fabricated the item and occasionally refurbished an item from a previous launch.

Contract members were also involved in the analysis of mechanical components to recommend improvements. This contract was completed on 30 September, 1981.

DESCRIPTION OF WORK

The object of the Upper Atmosphere Research Program is the acquisition of knowledge of the physical and chemical properties of the upper atmospheric region by experimentation carried on with instrumentation borne aloft by probing rockets and balloons.

The tasks assigned to Wentworth Institute of Technology during the term of this contract were in support of experiments undertaken by the Composition Branch, LKD, Aeronomy Branch of the Air Force Geophysics Laboratory. These tasks involved the design, fabrication, modification, assembly and testing of instrumentation under guidelines specified by the Composition Branch.

One major undertaking during the first part of the contract was the generation of a design layout of a Cluster Ion Mass Spectrometer. The initial design was developed through consultations between personnel at AFGL and WIT. These meetings led to the establishment of instrument design parameters. Assembly, subassembly and detail drawings were generated by the design section at WIT.

The Cluster Ion Mass Spectrometer consists of a two piece cone section with the top cone section electrically biased with respect to the lower cone. The front cone has an orifice opening of .03 - .04" diameter for ion sampling. The cone assembly was attached to a liquid helium cooled cryo pump supplied by another contractor. Attached to the bottom side of the liquid helium cryo pump is the base plate. "O" rings provided the vacuum seal between the base plate and cryo pump. The rod housing was fixed to the base plate and extended upward through the pump section. A RF quadrupole assembly extended to the upper region of the front cone sampling area and downward to an ion detecting electronic multiplier. An aluminum ring was externally attached to the base plate to support the electronics section of the instrument. This section consisted of a series of leg supports attached to a deck plate which holds an electronics box and other housekeeping equipment. Below the deck and attached to it is a complex cast aluminum housing containing electronic equipment. This entire section was enclosed with a vacuum tight electronic cover can.

After the completion of the design layout of the Cluster Ion Mass Spectrometer (C.I.M.S.) many modifications and adjustments were made in order

to improve the performance of the unit. These modifications are described below along with work on various other projects.

A drawing of a new electronics cover can was generated. The material was changed from stainless steel to aluminum. The wall and plate bottoms were made thicker and a high dielectric enamel coating was added to the interior surfaces of the can. This coating was necessary to prevent arcing between the interior can wall and the C.I.M.S. unit. Drawings 78-50C, 78-41B and 78-52B were generated of aluminum oxide rod spacers and will be used on any later units superseding the old spacer drawings. These drawings incorporate a new quadrupole bolt circle spacing.

Three gas transport handling spheres were fabricated in the Machine Shop. Initially six heavy duty stainless steel bowls were purchased. A reinforcing plate, a 1" diameter tube extension and a 2 3/4" diameter con-flat flange were T.I.G. welded to the end of each of three bowls. All bowls were then electro-polished, cleaned and sent out to have the interior surfaces gold-plated. A nickel strike was made in the process to form a sound base surface for the deposit of the gold surface. The gold plated surface was .0001" to .0002" thick.

After gold plating, the hemispheres were mated and T.I.G. welded to form a sphere with a con-flat flange at one end. To this flange a Grandville Phillips 1" diameter gold seal valve was mounted. The three spheres were delivered to the AFGL Composition Branch, Whole Air Sampling Lab.

A discussion was held at the Composition Branch on modifications to an existing cryopump. This involved incorporating a Quadrupole Mass Spectrometer and an associated electronics package mounted integrally with the cryopump and flown on a balloon launched gondola. A preliminary layout was made showing a method of raising and lowering the Cryopump Mass Spectrometer.

Vacuum leak checks were performed on the existing cryopump. Several leaks were found, the unit was dismantled and the leaks repaired.

Two tri samplers used in the upper atmospheric composition studies were modified. The Swage-lock fittings, which attached the blower exhaust assembly to the ultra-high vacuum valves on the samplers were removed and replaced by "Cajon VRC" vacuum connections. The change was necessitated by the fact that the Swage-lock connections had proved unreliable in vacuum tests in the field.

Nine valves and three blower exhaust assemblies were modified to accomodate the "VRC" connections.

A layout of the forward orifice sampling area was made. The layout was required to determine the design parameters for a new grid cone assembly which will be mounted on the quadrupole rods. It is electrically insulated from the rods and is mounted as close to the sampling orifice as possible. Various parts of the grid cone assembly were fabricated in the Machine Shop.

An existing cryopump was fitted to a balloon launched ion mass spectrometer. Both the cryopump and mass spectrometer were modified. Larger diameter tubular quadrupole rods were substituted for the solid rods used in the past.

An assembly drawing of an electronics housing was made. This housing replaced a cast version. The new housing as designed can be varied in size as required to fit in all component parts for a particular application.

The design of the C.I.M.S. front end was modified to increase the sensitivity of the unit. To this end, a conical S.S.T. sheet metal truncated cone piece brazed to a cylindrical ring was designed and fabricated.

The front plates of four existing LASSII housings were removed. Machining of the housings was done to modify them to accomodate new front plates.

Detail drawings were made of the following B.I.M.S. items: electronics housing support plate, base plate connecting the B.I.M.S. to the cryopump, quadrupole housing, oscillator support plate, support legs, insulator shield, rod spacer insulators, mounting plate for the ion multiplier unit, shield plates for support, front orifice cap, grid cap on the multiplier end, quadrupole rods, target insulator and an ion shield. An "E" size cross sectional drawing was made to aid engineering design. Ten 10" diameter Con-flat flanges to fit 6" O.D. tube for a vacuum chamber were made along with three each of side, back, bottom and top plates for an electronic housing. Three housings were assembled from these parts for the electronic mass spectrometer. One of these housings was delivered to the Electronics Department at Northeastern University. After consultation, modifications were made to all three housings.

A partial listing of typical items fabricated by the Machine Shop on various projects follows:

Project C.I.M.S.

Quantity	Description
2	Pull off caps, modified; added tapped holes LKD78-4B
1	Milling fixture for Pull off caps, LKD78-4B.
1	Grid Mandrel.
4	Mounting rings for Multiplier Housing Target Plate, LKD78-18B
1	Wire mesh screen assembly.
3	Grid Plates, LKD77-60B
6	Adaptor Rings, modified: LKD77-94D.
	Machined Chamfer on O.D.
	6 tapped holes on face
	8 tapped holes on circumference
	Made rotary fixture for adaptor rings.
6	Electronic Longeron Supports, Stainless Steel LKD77-96B.
6	Transformer Mounting Plates for Power Supply
1	Phenolic Electronic Longeron Support, LKD77-96B
6	Adaptor Plates, modified: LKD77-93B
	Added 14 holes, conterbored 6 holes.
	re-bored I.D. to 5.187"
	Made rotary table fixture for plates.
1	Adaptor for vacuum system
14	Stand-offs for multiplier Housing LKD78-5D
2	Modified Blower Housings:
	Removed 3 Flex Tubes from each unit
	Modified 6 3/4" swage lock fittings to fit housings.
3	Conflat Flanges, modified and made tubes to fit flanges.
1	Modified Cryolab Valve Rotatable Conflat to fit ¼" Swage Lock
	Weld Adaptors.
5	2 3/4" Conflat Flanges machined to fit Swage Lock unions.
12	10-24 x 2 ½" Brass Screws necket to root diameter.
	Bored hole in Cryo Dewar to fit valve body.
2	Flex tube adaptors for air intake unit.
4	2 1/8" dia. Rotatable Conflats, modified to fit Flex Tubes
2	Helium fill tubes for Cryodewar, modified.
2	150 c.c. Gas Sampler Tubes, modified.
2	3.500" End Tabulations for 150 c.c. Gas Sampler Tubes.
2	End Caps for 150 c.c. Gas Sampler Tubes

Quantity	Description
6	Shield Stand-Offs for Cryo Dewar, modified.
6	Quadrupole Rods, LKD78-44B-1
6	Quadrupole Rods, LKD78-44B-2
3	Multiplier Housings modified, Verbal Rebored inside diameter to .875
2	Thermistor Holders for Cryo Dewar, Sketch
2	Quadrupole Housings Reworked, LKD77-43D Elongated and widened 10 slots to reduce weight.
2	Rod housings reworked, LKD77-22D Major removal of stock on sides and flanges to reduce weight. A Milling fixture was made to accomplish this. Outside diameter reduced on two existing adaptor rings, for electronics cover Rebored inside diameter of rib section to two quadrupole housings to allow more clearance
2	Electronic Cover Cans (aluminum), LKD78-47D
4	Base Plates (LASS I) modified to fit feed-thrus, Sketch
4	Cover Plates, modified, LKD77-100D. Removed broken feed-thrus and cut air release grooves on three plates. Machined recess on back side of one plate. Reworked two electronic cover cans, LKD78-47D. Rebored inside diameter on open end to remove excessive hi dielectric material. Removed welded bead on outside diameter.
1	Housing, for Rocket Unit, LKD76-132B
2	Pull-off caps for M.S. Sensor, LKD76-132B
2	Aperture Covers for M.S. Sensor, LKD76-131B Grinding of Special tool was required for dovetail of "O" Ring groove.
8	Retainers for Marmon Clamps, LKD78-39A
2	Teflon bushings for inlet of cryopump, Sketch
1	Ion Lab Test Fixture, LKD79-1D
8	Aperture discs for Air Sampler (Ion Source), LKD79-2B. A turning fixture was made for these.
1	Clamp Plate for Lab Fixture, LKD79-1D

Quantity	Description
	Modified Top Plate of Lab Fixture, LKD79-1D
2	Nipples modified (Eclipse), Sketch
2	Quick disconnect fittings modified (Eclipse), Sketch
2	Tube extensions (Eclipse), Sketch
1	Valve Body Modified (Eclipse), Sketch
1	Tee Modified to fit Valve Body (Eclipse), Sketch
1	Pump Out Adaptor Plate for Electronics Can
20	Supports, Radial, LKD77-65B
	Modifications on Lab Test Unit, LKD79-1D
1	Rod Housing, Rocket Instrumentation LASSII, LKD78-49D
9	Quadrupole Rods, LKD78-23B1
9	Quadrupole Rods, LKD78-23B1
4	Modified Quadrupole Rods, LKD77-47B
12	Quadrupole Grid Apertures (LASSII), Sketch
1	Quadrupole Grid Aperture Turning Fixture
17	Cone Layouts, .002", .002" and .003" Thick
2	Cone Shaped Fixtures for Cone Layout, Sketch
3	R.F. Oscillating Box Housings
3	R.F. Oscillating Box Back Plates, LKD77-87C
1	R.F. Oscillating Box Milling Fixture
3	R.F. Oscillating Box Lower Deck, LKD77-84B
3	R.F. Oscillating Box Bottom Plate, LKD77-82B
3	R.F. Oscillating Box Deck #1, LKD77-85B
3	R.F. Oscillating Box Deck #2, LKD77-86B
3	R.F. Oscillating Box Side Plate, LKD77-89B
3	R.F. Oscillating Box Covers, LKD77-88C
3	Assembled R.F. Oscillating Boxes, LKD77-90B
8	Grid Plates, LKD77-60B
1	Grid Plate Fixture
1	Lower Split Cone Spot Welding Fixture for Front End of Quadrupole Section, Sketch
8	Front End Cone Layout Pieces, Sketch
15	KEL-F Insulator Spacers, Sketch
1	Special Fixture to hold all lengths of Quadrupole Rods for Milling and Drilling operations.

Quantity	Description
6	Quadrupole Rods, LKD78-47B-1
6	Quadrupole Rods, LKD78-47B-2
6	Quadrupole Rods, LKD78-44B-1
6	Quadrupole Rods, LKD78-44B-2
1	Split ring clamp flange for the vacuum table
4	Grid Plates for LASSII housing, LKD76-122-B
3	Orifice Plates, LKD76-123-C
5	Contact Plates, LKD78-11-C

Project S.E.P.S. (Shuttle Effects on Plasma in Space)

Machine Shop

Completed

Quantity	Description
1	Housing front plate LKD-78-48D
7	Grid Plates LKD80-21B-1
5	Grid Plates LKD80-21B-2
18	Grid Plates LKD80-21B-3
1	Milling and turning fixture to machine the above grid plates.
2	Grid Caps (Ion Box) LKD80-22B
16	Grid Rings .438" outside diameter, .187" inside diameter, .005" thick (.438" x .187" x .005")
16	Grid Rings (.380" x .128" x .005")
1	Electrode assembly #1 LKD73-83C-2
3	Nupro valve handles modified
3	KEL-F insulators (rod housing) LKD80-25C
15	4-40 Cap screws slotted to thread depth
2	Brackets modified
1	Insulator for the Ion Box LKD80-38C
16	Spring Retainer clips (Blow-off cap) LKD80-39B
1	Modified photo multiplier housing
16	Grid Rings (.780" x .531" x .005")
16	Grid Rings (.656" x .406" x .005")

Quantity	Description
10	2-56 Screws slotted to thread depth
3	Grid Caps for the photomultiplier LKD80-27A
1	Milling Fixture for machining the above grid caps
6	Plates #3 side LKD72-87A

Project S.E.P.S.

Machine Shop

Quantity	Description
4	Insulators, Rod Housing LKD80-25C
1	Modified SWAGE Lock fitting
1	Leak detector adaptor
6	Side mounting plates for the electronics box LKD76-147A
1	Bellows coupling
2	Bellows adaptors
6	Short plates LKD72-90A
5	Stand-offs for the filament support LKD80-40B-2
1	Electrode assembly #1 LKD73-83C-1
9	Quadrupole Rods LKD80-24B-1
9	Quadrupole Rods LKD80-24B-2
2	Flexitube adaptors
2	Housing front plates to fit modified housings
1	Housing for rocket unit
1	The ion pump housing was reduced in diameter to 5.000 in.
2	Existing housings were modified. The welded front plate was removed and rebored to fit extended front plates.

Project SPE (Solar Proton Event)

Machine Shop

Quantity	Description
4	Modified orifice front plates LKD80-45C
2	Bellows adaptors
4	Grid plates for the rod housing
11	Grid rings LKD80-47B

Project SETS

Machine Shop

Completed

Quantity	Description
2	Nose cone supports LKD81-2-B
2	Cone tip guides LKD81-3-A
2	Blow off covers LKD81-4B
1	Rocket unit housing was modified to accomodate a cryolab valve.
1	A cryolab valve was reduced in length
2	Blow off nose caps LKD81-C
1	Mounting template for the electronics box
1	Mounting template for the electronics box cover LKD79-21D.
1	A cryolab fitting was removed and a plug was made to fit the inside diameter of an existing housing for the rocket unit.
1	Mock-up of electronics box and base plate.

Parts of Mock-up completed

1	Housing (MMD81-9D)
1	Set of arm links (C2859)
1	Top ring (C2856)
1	Motor driver cap (C2857)
1	Cover stop

Parts of Mock-up in progress

1	Cover hinge block (B2862)
1	Gear housing
1	Logic box for the motor
1	Valve support (9LKD76-116B)

Mechanical Design

Completed	Description
1	Electron beam welding of plate and cryolab valve to housings.
2	Three fittings were electron beam welded to two bellows and the bellows were joined.
3	Three filaments were installed in filament holders.

Project B.I.M.S.

Machine Shop

Quantity	Description
1	Vacuum gauge vessel

Quantity	Description
1	Vacuum gauge vessel cap
2	Conflats were reworked. Tapped holes, O-ring grooves and a bored center hole were added to fit a Varian vacuum gauge.
1	Plexiglass disc 10" diameter by 1" thick for a lab simulation chamber.
2	Stainless steel couplings 4.250" long by 3.875" outside diameter.

Mechanical Design

Completed

Quantity	Description
1	Electron beam welding of 2 Varian conflat flanges to Varian vacuum gauges.
2	A plug was welded to an ion mass spectrometer housing.
3	A leak was repaired in an ion source housing.
10	10" diameter Con-flat flange to fit 6" O.D. tube for a vacuum chamber.
3 each	Side, back, top and bottom plates for electronic housing.

Three housings were assembled from these parts for the electronic mass spectrometer. One of these housings was delivered to the Electronics Department at Northeastern University. After installation of some electrical equipment, Wentworth and Northeastern personnel held a consultation. As a result modifications were made on all three housings.

Quantity	Description
1	10" diameter plexiglass disc.
1	10" diameter collar for a vacuum chamber.
2	Shield supports.
3	Shield plate holders.
4 each	Upper and lower quadrupole rods
2	Mounting brackets.
1	Tie down plate.
4	Shield brackets.
1	Hinge bracket.
1	Lever arm.
2	Pivot arms.
1	Aperture cap.
1	Coupling between adjusting rod and motor for vacuum chamber test unit.
1	Motor mount bracket for the vacuum chamber.

Quantity	Description
6	Hubs bored out and bronze bushings pushed into three inch pulleys.
4	Inside diameters of Marmon clamps were reduced.
2	Couplings for a Dewar.
1	Helium and Nitrogen fill ports for a Dewar.
1	Bottom plate and adaptor connector for electronics housing.
1	Aperture plate.
2	Shield supports.

Mechanical Design

Completed Drawings

1	Front cover.
2	Aperture plate.
3	Bracket assembly.
4	Blow off cap layout
5	Pull off arm.
6	Lever arm.
7	Hinge Bracket.
8	Tie down plate.
9	Pivot pin.
10	Aperture cover.
11	Squib shield bracket.
12	Rod spacers.
13	Target insulator.
14	Support hanger for the balloon gondola.
15	Helium and Nitrogen inlet parts cover.
16	Gondola layouts I and II.
17	Front orifice port.

Gerdien Condenser

Mechanical Design

Quantity	Description
1	LKD 81-001D Gerdien Condenser Assembly.
1	LKD 81-002D Outer housing
1	LKD 81-003C Cone Section

Quantity	Description
1	LKD 81-004C Inner housing-short
1	LKD 81-005C Inner housing-long
1	LKD 81-006C Frustum Section
2	LKD 81-007C Connecting ring
1	LKD 81-008C Cone ring
1	LKD 81-009C Mounting flange
1	LKD 81-010C End plate
6	LKD 81-011C Support legs
1	LKD 81-014C Clamp Block for the mounting block.
1	LKD 81-015C Anti-vibration gasket
1	LKD 81-017C Gasket ratainer
2	LKD 81-018D End housings (P-1 and P-2)
1	LKD 81-019D Center housing

Work for Whole Air Sampling Lab

Machine Shop

Quantity	Description
2	Connector Adaptors 4.250" long by 3.875" outside diameter.

Project NAMS

Machine Shop

Quantity	Description
3	Filament supports.
2	Grid caps for the ion box. A milling and turning fixture was made to maching the grid caps.
12	Quadrupole rods.
1	Radio frequency shield for the photomultiplier housing. A second shield was made due to dimensional changes requested after completion of the first shield. A milling and turning fixture was made to machine the shields.
3	Modified marmon clamps.

CONCLUSION

In this report no attempt has been made to detail the technical aspects of the varied processes followed in the Design Section or Instrument Shop. The pertinent information was evaluated and used by the AFGL at the time of its generation. The design effort was directed by Mr. Edgar LeBlanc and the Instrument Shop output by Mr. Otto Molter.

During the term of the contract purchases of equipment and supplies were requisitioned as needed. The only travel involved was that associated with trips to the Composition Branch, LKD, in Bedford, Massachusetts, for the purpose of establishing design requirements as mentioned in this report.